Development of the Dashboard of Ecosystem Indicators for Puget Sound

The Puget Sound Partnership's Indicators Action Team

Introduction

In 2007, the Washington State Legislature enacted Engrossed Substitute House Bill 5372 creating the Puget Sound Partnership (PSP) with a mandate to restore the health of Puget Sound by 2020. This mandate was defined according to six goals: 1) A healthy human population supported by a healthy Puget Sound that is not threatened by changes in the ecosystem, 2) A quality of human life that is sustained by a functioning Puget Sound ecosystem, 3) Healthy and sustaining populations of native species in Puget Sound, including a robust food web, 4) A healthy Puget Sound where freshwater, estuary, near shore, marine, and upland habitats are protected, restored, and sustained, 5) An ecosystem that is supported by ground water levels as well as river and stream flow levels sufficient, to sustain people, fish, and wildlife, and the natural functions of the environment, and 6) Fresh and marine waters and sediments of a sufficient quality so that the waters in the region are safe for drinking, swimming, shellfish harvest and consumption, and other human uses and enjoyment, and are not harmful to the native marine mammals, fish, birds, and shellfish of the region.

By design, restoration of the Sound is to be guided by a science-based Action Agenda describing a list of priority activities to be updated over time. In turn, the scientific underpinnings of the Action Agenda would be developed in the Puget Sound Science Update (PSSU), a recurring characterization of environmental and social condition in the Puget Sound Ecoregions. Specifically, the PSSU would describe: 1) the current scientific understanding of physical attributes of Puget Sound, 2) a scientific process for selecting environmental indicators measuring the health of Puget Sound, and 3) guidance on how to establish targets for environmental indicators. Shortly after the PSP was created, the scope of the PSSU was expanded to include a description of the social, human health and human wellbeing of the Puget Sound region and a scientific basis for selecting additional indicators including human health and well-being indicators.

Also known as the Partnership's enabling statute, this state law called for the establishment of ecosystem indicators by July 2008. Consequently, the Partnership attempted to develop a limited set of science-based measurements that accurately reflect the status of the Puget Sound ecosystem. However, by 2010, the Partnership had not yet selected a final set of ecosystem indicators. Thus, in February 2010, the Indicators Action Team (IAT) was formed as part of the newly designed and launched performance management system. This new system would bring the organization into compliance with the statute while responding to the Partnership's leadership, the Governor's Office and the Environmental Protection Agency's leaders who considered performance management a high priority to be implemented.

In March 2010, scientists and other leaders were selected by Partnership staff to form the IAT. Expertise of team members covered the natural and social sciences with members drawn from federal and state agencies and non-governmental organizations. It was most important that the Team include positive, like-minded professionals who would likely collaborate well together and get the job done, on time.

Team members were invited toparticipate in an initial meeting, with other team members added over subsequent meetings based on perceived gaps in expertise. The Team's work was facilitated by the Partnership's Performance Manager and assisted by two students. The IAT was composed of:

- Leonard Bauer, Department of Commerce
- Helen Berry, Department of Natural Resources
- Mary Beth Brown, Puget Sound Partnership
- Rob Duff, Department of Ecology

- Angela Grout, US Environmental Protection Agency
- Ken Currens, Northwest Indian Fisheries
- Phil Levin, National Oceanic and Atmospheric Administration
- Tim Quinn, Department of Fish and Wildlife
- Trina Wellman, Northern Economics, Inc.
- Jacques White, Long Live the Kings
- Bethany Johnson, University of Washington (student)
- Brian Payne, University of Washington (student)
- John Becker, Puget Sound Partnership, Team Facilitator

It was believed that the mix of scientific expertise, organizational affiliation and management wisdom represented by these Puget Sound-based leaders would be just the right combination of influences to support launching the Partnership's new Performance Management efforts.

The IAT was charged by PSP leadership with developing between 12 and 20 environmental indicators by July 2010. The selected indicators eventually became known as the Dashboard of Ecosystem Indicators (the Dashboard). The Dashboard is defined as a relatively small, representative collection of interconnected natural, human and program dimension indicators that reflect both short- and long-term progress for restoring the health of Puget Sound. The Team agreed that an effective Dashboard should:

- provide an ongoing snapshot of the overall health of the Sound
- show the collective impacts of new and ongoing management strategies
- reveal the results for key ecosystem, human and program dimension measurements in advance of State of the Sound reports
- be ecologically important and socially resonant

The Dashboard presented here is primarily composed of status and trends type indicators.[1] The IAT acknowledges that the Dashboard does not represent all of the indicators that may be needed to measure the health of Puget Sound. Instead, the Dashboard's indicators are to serve as high-level, outcome type measures of the health of Puget Sound and of the health and well-being of the people of Puget Sound. Additional indicators will be necessary to evaluate the effectiveness of specific management actions and to assess specific aspects of the natural and human systems involved.

Development of the Dashboard of Ecosystem Indicators for Puget Sound: Standing on the shoulders of previous Puget Sound indicator efforts

The development of the Dashboard in alignment with the critical components of the ecosystem is built upon the foundation of previous indicator work conducted by the PSP and Its predecessor organizations. In particular, the Dashboard uses approaches outlined in the following sources:

- Chapter 1 of the Puget Sound Science Update (PSSU)
- Environmental Indicators for the Puget Sound Partnership: A Regional Effort to Select Provisional Indicators (Phase 1)

[1] Status and trends monitoring can be thought of as broad, integrated and long-term effectiveness monitoring of a wide array of management strategies. More specific, project effectiveness monitoring is needed, however, to assure that successful management actions are propagated as part of a strategy while ineffective ones are discontinued. Likewise when our management actions have unknown and potentially complex consequences, cause and effect monitoring can be used to understand the connection between actions and ecosystem outcomes.

- PSP Action Agenda
- 2009 PSP Technical Memoranda: Identification of Ecosystem Components and Their Indicators and Targets
- Ecosystem Status and Trends, a literature review on human well-being indicators including a ranking of potential indicators using criteria established by the NOAA NW Fisheries Science Center staff (O'Neill, Bravo and Collier, 2008)
- Input from social scientists and stakeholders in the Performance Management/Open Standards process conducted by PSP staff (PSP, 2009)
- Review of human well-being indicators in Part 2b of the PSP Science Update (Mercer et al, 2010)

Outlined below are the logic, principles, and rationale used by the IAT in developing indicators for the Dashboard.   Appendix B outlines the specific steps that led to identification of the natural dimension indicators. Details concerning the IAT's selection of the Dashboard's human dimension indicators are shown in Appendix C.

Based on the philosophy of the Open Standards for the Practice of Conservation

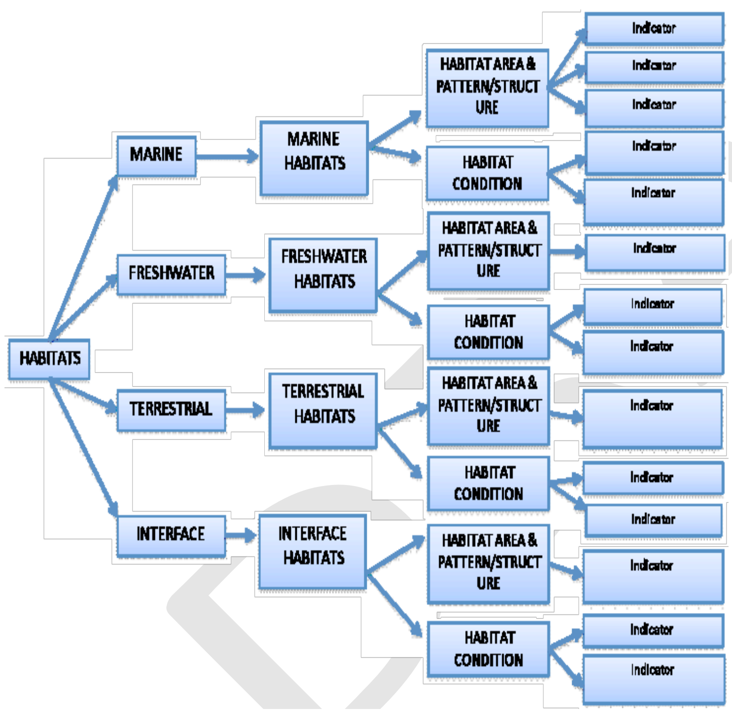

Figure 1. Example of linkage between PSP Goals and indicators as redrawn from the Puget Sound Science Update. Chapter 1

The IAT employed a straightforward approach to organize indicators into logical and meaningful ways in order to assess progress towards policy goals. We used the PSSU Chapter 1 framework, which was derived directly from the implementation of the Open Standards for the Practice of Conservation in Puget Sound. Our framework thus begins with the six Goals of the PSP. We then decomposed those goals into unique ecological Focal Components within specific habitat domains (i.e., marine, freshwater, terrestrial, and interface/ecotone) or as related to human dimensions. Each focal component is characterized by key attributes, which describe fundamental aspects of each focal component. Finally, we map Indicators onto each ecosystem key attribute. We define **indicators** as bio-physical or socio-economic measurements that serve as proxies of the conditions of key attributes of natural and socio-economic systems, whereas **ecosystem attributes** are characteristics that define the structure, composition and function of the ecosystem that are of scientific and/or management importance, but insufficiently specific and/or logistically challenging to measure directly. Thus, indicators provide a practical means to judge changes in ecosystem attributes related to the achievement of management objectives.   The framework is illustrated in Figure 1 above for the Habitat goal. Adoption and use of this framework ensured that the IAT kept in mind how Dashboard measures related to PSP goals, focal components and key attributes.

Considering a broad range of diverse indicators

We began populating the framework described above with indicators by first gathering all indicators previously selected for use by the PSP. Chapter 1 of the PSSU compiled a comprehensive list of such indicators including:

- About 250 indicators from "Environmental Indicators for the Puget Sound Partnership: A Regional Effort to Select Provisional Indicators (Phase 1)" that were considered "good," "potential," or "possible future."
- 102 environmental indicators that were listed in the PSP Action Agenda based on a review by the PSP Science Panel.
- 160 indicators from the process specifically guided by the Open Standards for the Practice of Conservation
- 43 indicators from the PSP Technical Memorandum, "Ecosystem Status and Trends," (a subset of these were used in the 2009 State of the Sound report).
- >150 water quantity indicators derived from a literature review of indicators that may track various aspects of the hydrologic flow regime.
- The entire set of indicators was combined and redundant indicators removed, and then organized according to goals, ecosystem components and attributes of our framework.

Considering the specificity and sensitivity of indicators

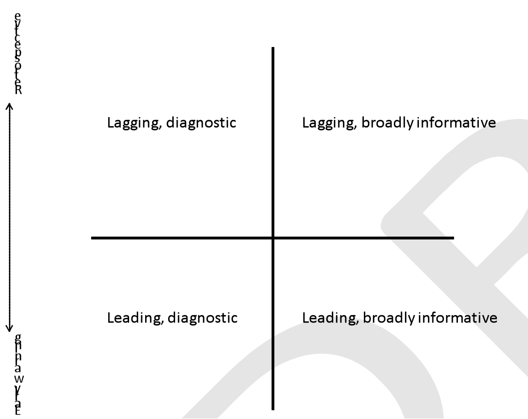

Figure 2. Specificity and sensitivity display of ecosystem indicators

The IAT thought that a useful way to evaluate indicators was to consider in more detail the evaluation criterion "the indicator responds predictably and is sufficiently sensitive to a specific ecosystem attribute." Two of the terms in this criterion, "specific" and "sensitive," can be used to organize indicators according to the type of information they provide about attributes. An indicator's specificity depends on whether it reliably tracks few or many attributes. An indicator that provides information about many attributes is non-specific but broadly informative, while that which serves well as a proxy for fewer attributes can be thought of as diagnostic of changes in specific ecosystem conditions. Another informative axis on which to interpret an indicator is in terms of its sensitivity. An indicator that provides information about impending changes in attributes before they occur is an early warning or "leading" indicator. In contrast, an indicator that reflects changes in attributes only after they have occurred is a retrospective or "lagging" indicator.

The IAT thus considered how highly-ranked, natural dimension indicators mapped along the axes of specificity and sensitivity by roughly plotting them on a graph such as the one shown above.[2] The objective of this exercise was simply to be cognizant of what type of information each indicator would provide, and to avoid selecting too many indicators from a single quadrant. No value judgment was made about individual quadrants (i.e., a leading diagnostic indicator was not considered any better than lagging, broadly informative indicator). Based on this

[2] A detailed description of the indicator evaluation process can be found in Chapter 1a of the Puget Sound Science Update. Appendix B outlines how the IAT applied the PSSU framework to the Dashboard Indicators.

four quadrants approach, three Portfolios of potential indicators were assembled by the IAT. This helped the Team and other PSP groups consider various options in selecting natural dimension indicators for the Dashboard.

In assembling the natural dimension indicators for the Dashboard, the team explicitly viewed this as the creation of a portfolio of complementary indicators. The objective was not to represent every ecosystem attribute, every process or every species in the Sound, but rather to assemble a scientifically credible portfolio of indicators that would provide a breadth of information about different ecosystem components over different temporal and spatial scales.

Using all available information, the IAT developed three alternative Dashboard indicator portfolios (see Appendix A). Each portfolio is scientifically robust and meaningful, and taken as a whole can be considered to be the “vital signs” of Puget Sound in a similar way that blood pressure, heart rate, and temperature may be seen as the vital signs of human health. The Team chose Portfolio A, which represents the Team’s consensus as the best indicators for the Dashboard. Portfolios B and C are equally scientifically credible, but emphasize slightly different parts of the ecosystem.

Table 1. Recommended Dashboard of Ecosystem Indicators for Puget Sound

Natural Dimension	**Human Dimension**	**Program Dimension**
Marine Water Quality Index	Sound Behavior Index (under construction)	Funding for Action Agenda
Freshwater Quality Index	Puget Sound Quality of Life Index (under construction)	Percent of Action Agenda Items Addressed
Stream Flows Below Critical Levels	Tribal/Non-Tribal Commercial Harvest	
Wild Chinook Salmon	Swimming Beaches	
Orcas/ South Resident Killer Whales	Recreational Fishing Permit Sales	
Pacific Herring	Shellfish Beds Restored	
Birds		
Shoreline Armoring		
Eelgrass		
Toxics in Fish		
Toxics in Sediments		
Land Use/Land Cover		

NOTE: Table 1 represents the Dashboard of Ecosystem Indicators for Puget Sound but is not identical to the original indicators selected as Portfolio A by the IAT. The differences reflect changes following external input/comments received, further discussion amongst the IAT and guidance from PSP.

There is nothing magical about these three portfolios. They balance a wide variety of indicators across the natural, human and program dimensions of the Dashboard, the five Action Agenda goals and have degrees of sensitivity and selectivity. Our aim was to get similar balance among the three portfolios across the two axes of sensitivity and selectivity. Other criteria not considered could be important to choosing one indicator over its alternative. For example, upon careful examination of logistical issues associated with sampling, we may find that it is twice as expensive to collect data on one indicator versus its alternatives. It will be wise to retain some flexibility in choosing and improving specific indicators for the same attribute over time until feasibility assessments (sampling plans) can be completed and any risk associated with lagging indicators can be assessed.

No explicit effort was made to rank indicators or portfolios by their social resonance or marketing potential. The IAT felt that this was a judgment best left to others. Indeed, the Team strongly urges a careful and rigorous examination of the social value of these portfolios over time. We emphasize that these portfolios are built on the foundation of all the PSP indicator efforts from the past as well as the work by PSP's precursor organizations.

Review and modification of proposed indicators

The process for choosing these 20 indicators was, by necessity, a blend of scientific evaluation and expert opinion. It was based on the understanding that the IAT needed to limit the number of indicators they could consider to represent status of the ecosystem, how the Dashboard Indicators would be used and interpreted, and a necessity to complete this work by July 2010.

Although the IAT attempted to separate scientific from social or political criteria, the selection of indicators was influenced by the Team's perspective of what would be socially resonant. For example, out of many potentially informative indicators, we chose wild Chinook salmon and orcas because we believe them to be iconic species in Puget Sound. Likewise, although the IAT recommended jellyfish, the Team later replaced jellyfish with herring. Although jellyfish are a demonstrably stronger ecosystem health indicator than herring, herring was ultimately selected based on the presence of historical data on herring as well as comments received during meetings of the Science Panel, Ecosystem Coordination Board and Leadership Council. Thus, it is important to acknowledge that the proposed indicators were affected by the opinions and perceptions of the IAT, other PSP leaders and a variety of ad hoc commenters. Importantly, input external to the PSP was not broadly or systematically solicited, and as a result may not be generally representative of scientists, managers or citizens in the region. It is possible that a different group of individuals serving on the Indicators Action Team would have chosen a different group of indicators or may even have failed to complete this work within the timeframe required.

Selection of Human Health indicators

In keeping with the goals of the Action Agenda, two human health indicators were chosen by the IAT to include:

- Swimming beaches
- Shellfish beds restored (an established indicator of success with the Environmental Protection Agency)

Selection of Human Well-being indicators

Plummer and Schneidler, 2009 and Chapter 2b (in draft) of the PSSU guided the compilation of a comprehensive list of human wellbeing indicators. Human wellbeing indicators were chosen for the Dashboard based on representation in one or more of each of the following six focal components as provided in the Open Standards process.

1. Regional makeup (including demographics, economic, water use and transportation trends).
2. Social capital (e.g. environmental stewardship, citizen scientists)
3. Impact of recovery strategies on marine and land based natural resource industries (unintended consequences of Action Agenda implementation)
4. Ecosystem services which provide benefits to people
5. Behavioral change of public as awareness increases
6. Existence value of the ecosystem (including aesthetics and willingness to pay to assure the continued survival of individual species or general health of the ecosystem)

This list of strategic outcomes has appeared repeatedly throughout the Partnership's work on human well-being indicators. For the purposes of our 2010 Dashboard, indicators with current robust data sources were selected for four of the six focal components:

- Regional makeup – *Puget Sound Regional Council's Trends Index*
- Impact of recovery strategies on marine and land based natural resource industries – *Commercial Fisheries Harvest (Tribal and Non-Tribal; annual wild harvest in pounds)*
- Ecosystem services which provide benefits to people – *Participation in recreational fish, shellfish and hunting harvest (number of permits issued)*
- Behavioral change of public as awareness increases – *Personal vehicle miles traveled*

Again, as indicated above, ad hoc comments and perceptions led to changes in the final list of human wellbeing indicators. It was decided that the regional makeup and behavioral change focal components required the generation of two new indices of "Puget Sound Quality of Life" and "Sound Behavior" with respective data needs. These two indicators replaced the Trends Index and Personal vehicle miles traveled and are currently under development by PSP staff.

Selection of Program indicators

Finally, two program indicators were selected to provide an Action Agenda accountability focus on the Dashboard, as well:

- Funding for Action Agenda
- Percent of Action Agenda items addressed

Next Steps

Two key elements of a rigorous evaluation of the Dashboard indicators may still need to occur, and may or may not lead to a different suite of Dashboard indicators. First, the social resonance of these indicators needs to be tested using methods developed by social scientists. This should routinely be accomplished as we move forward. The Indicators Action Team does not represent a cross section of the public, and thus is incapable of rendering unbiased judgment on the social value of the indicators. Careful research will reveal how and why citizens use the Dashboard, and may influence which indicators are determined to be most useful over time.

The development of the Dashboard of Ecosystem Indicators has been a performance management-, policy- and science-driven process, and although external peer review is fundamental to the scientific process, the Dashboard was not subjected to such a formal review. In addition, the Dashboard has not been widely available for scrutiny by the Puget Sound scientific community. Ideally, this work would have been more broadly shared throughout the scientific community before the Dashboard was launched, but time did not allow prior to the Dashboard's launching. This will occur in the future as part of the routine review and improvement of the Dashboard indicators going forward. Additionally, enlisting the input and support of the community at large is crucial to the Partnership's success.

Launching the Dashboard is simply the beginning of selecting, evaluating and improving ecosystem indicators for Puget Sound. In addition to the steps outlined above (which will likely help to improve the Dashboard), other indicators or suites of indicators, in addition to the Dashboard indicators will need to be chosen. While the Dashboard should provide a sense of the overall health of the Sound, in general, the information it provides is not specific enough to most fully guide management actions. Further, more specific, diagnostic indicators will be required. For instance, a decline in the number of salmon may signal a problem, but that fact in itself does not reveal the specific nature of the problem. As a result, a number of more specific indicators of habitat, water quantity, water quality and food web processes may be needed to guide the appropriate management response.

Similarly, indicators of ecosystem drivers and pressures may need to be more fully developed. Although the Dashboard does include some indicators related to ecosystem threats, the Dashboard was not developed specifically with this sort of approach in mind. The Indicators Action Team discussed the possibility of future indicator development efforts possibly focusing on the key threats to the ecosystem (threat reduction indicators).

Finally, a major effort to establish targets for key indicators is just beginning as called for in the Partnership's enabling legislation. A new Target Setting process is being developed to structure and standardize the Partnership's target setting process over time.

Appendix A: Three Portfolios of Natural Dimension Dashboard Indicators

Portfolio A is the suite of indicators recommended by the Indicator Action Team. Portfolios B and C are presented as alternatives with equal scientific credibility. Each portfolio is also presented graphically showing the specificity (diagnostic versus non-specific) and sensitivity (leading versus lagging) of each indicator (see Figures A1, A2 and A3). Figures A4, A5 and A6 show the linage of each indicator associated ecosystem attributes and the six PSP goals.

Portfolio A is not identical to the final 20 indicators selected as the Dashboard of Ecosystem Indicators for the Puget Sound as presented in Table 1. Input received during external review and subsequent discussion among the IAT resulted in modifications of Portfolio A leading to the final Dashboard.

Portfolio A.

Indicator	PSP Goal	Sensitivity (Leading/lagging)	Specificity (Diagnostic/Non-specific))	Comments	Scientifically Suitable Alternatives
Number of Southern Resident Killer Whales	Species and food webs	Low	Moderately non-specific	Poor indicator of ecosystem health, but provides information on the status of an important ESA-listed species	Harbor Seals, rockfish
Number of wild Chinook Salmon	Species and food webs	Moderately high	Moderately non-specific	A good non-specific indicator of the status of freshwater / nearshore ecosystems and the status of an important ESA-listed species	Crab numbers
Number of Jellyfish	Species and food webs	High	Moderate	An excellent indicator of ecosystem structure and function, especially of energy transfer and pelagic community composition. Jellyfish abundance can be linked to fishing impacts, eutrophication, habitat modification (shoreline armoring), shipping traffic, and other human activities.	Herring can substitute for jellyfish in this portfolio, but serve as a proxy for fewer ecosystem processes. Chlorophyll A is an excellent indicator of energy and material flow through food webs. In this portfolio, it is included in the water quality index. If that index is removed, then Chl A, could be an alternative to Jellyfish (or herring)
Numbers key	Species and	Moderately Low	Diagnostic	Phenological timing of migrations	Numbers of Murrelets, Murrelets

Terrestrial Bird species	food webs			serves as a useful leading indicator of climate change impacts. Bird Community composition change indicates broad-scale (structure/function) land- use effects, Changes in cavity nesters indicate changes to specific habitat elements and cascading effects on cavity dependent species Marbled murrelets are sensitive to losses of a specific seral stage (old forest) and forest fragmentation.	subject to marine (food limitation and fishing mortality) and terrestrial disturbance (loss and fragmentation of old forests). Stillwater breeding amphibian, Indicator of land –use and fresh water quality/quantity. Phenological timing of breeding serves as a useful leading indicator of climate change impacts. Amphibian Community composition change indicates broad-scale (structure/function) land- use effects
Cover of eelgrass	Habitat	Moderate	Moderate	Eelgrass is a critical nearshore habitat. Several years of data are available. There remains much research to conduct to determine causes of decline and increases.	Harmful algal blooms. Although very different from eelgrass in what they represent, HABs are an important component of water column habitat.
Percent of shoreline armored	Habitat	Moderate	Diagnostic	There is general consensus that shoreline armoring is not good for the ecosystem, but debate remains about whether there are thresholds and what those values would be. Further the location of the armoring within a drift cell has a strong determinant on its affect. i.e., a small amount of armoring in the wrong place can have a bigger effect than a large amount placed elsewhere. It can be easily measured, and It is clear that cumulative effects of armoring is of major importance, especially within the context of other shoreline stressors.	Marine riparian condition. Like fresh water riparian, marine riparian structure (tall shade trees, organic matter and CWD input, water filtration) can influence shoreline functions (e.g., habitat for forage fish)

Land use / land cover	Habitat	Moderate	Diagnostic	Changes in extent and quality of ecological systems can represent threats to obligate species associated with those systems. Tracking land use and cover is consistent with coarse filter approaches to conservation. Also provide estimates of working land conversion rate, impervious surface changes, and changes to habitat, which are part of delisting criteria for salmon and other species	Human footprint analysis, which calculates an index of human effects on elements of biodiversity from coarse scale land-use/cover. More informative than simple changes to land cover and has growing empirical evidence support (e.g., Leu et al 2008)
Ecology Freshwater and Marine Water Quality Indices	Water quality	Moderate	Non-specific	The freshwater index is an index of key freshwater quality metrics compared to standards or expected conditions. Metrics include bacteria, pH, temperature, dissolved oxygen, nutrients and sediment. Provides a score 0-100. The contribution of individual metrics can be assessed as with all indices. The marine index is an index of key marine water quality metrics compared to expected conditions. Uses a modular approach to generate a eutrophication index which is combined with natural conditions yielding the overall composite index. Provides a score 0-100 while also displaying status and trends for each component.	
Ecology Sediment Quality Triad Index	Water quality	Moderate	Moderately diagnostic	An index of three sediment components: chemistry, toxicity and sediment-dwelling organisms. Data is collected on both a basin-wide and urban bay scale.	The sediment chemistry component is often looked at individually. This component of the triad is being refined to better quantify comparisons to Sediment Management Standards.
Toxics in fish	Water quality	Moderate	Moderately diagnostic	Measure of persistent bioaccumulative contaminants. Relevant to human	Toxics in Mussels

				health and food web toxic loadings.	
Violations of DOE instream flows	Water quantity	Low	Non-specific		
Percent of monitored stream flows below critical levels	Water quantity	Moderately high	Moderate	A seasonally-dependant measure of critical stream flow based on historical comparisons. Imperfect measure of water availability. While stream flows are impacted by groundwater, a more direct measure of groundwater availability is needed.	% time in-stream flows met August – September. A variation of the same measure based on regulatory levels set for minimum flows as opposed to historical comparisons.

Portfolio B.

Indicator	PSP Goal	Sensitivity	Specificity	Comments
Number of Harbor Seals	Species and food webs	Low	Moderately non-specific	Important predators in the system, and good indicator of fish community composition, and population condition. Historical data are present, with diet data available back to the early 1900's.
Number of wild Chinook Salmon	Species and food webs	Moderately high	Moderately non-specific	
Number of herring	Species and food webs	High	Moderate	*Responsive to* environmental conditions, making them a good indicator of ecosystem, but it is difficult to separate natural vs. human causes of their population fluctuations. They are an important diet item to a number of species of interest. They provide some of the same information as jellyfish, but jellyfish also are diagnostic of some human perturbations.
Numbers of Murrelets	Species and food webs	Moderately Low	Diagnostic	Phenological timing of nesting serves as a useful leading indicator of climate change impacts. Marbled murrelets are sensitive to losses of a specific seral stage (old forest) and forest fragmentation.
Cover of eelgrass	Habitat	Moderate	Moderate	
Percent of shoreline armored	Habitat	Moderate	Diagnostic	Measures "no net loss of ecological functions" goal as part of growth Management, and Shoreline Master Plans. Provides estimate of ecosystem process impairment –tied to many eco goods and services
Land use / land cover	Habitat	Moderate	Diagnostic	Changes in extent and quality of ecological systems; represents threats to obligate species associated with those systems. Tracking land use and cover is consistent with coarse filter approaches to conservation. Also provide estimates of working land conversion rate, impervious surface changes, and changes to habitat, which are part of delisting criteria for salmon and other species

Ecology Freshwater Water Quality Index	Water quality	Moderate	Non-specific	An index of key freshwater quality metrics compared to standards or expected conditions. Metrics include bacteria, pH, temperature, dissolved oxygen, nutrients and sediment. Provides a score 0-100. The contribution of individual metrics can be assessed as with all indices.
Ecology Marine Water Quality Composite Index	Water quality	Moderate	Non-specific	An index of key marine water quality metrics compared to expected conditions. Uses a modular approach to generate a eutrophication index which is combined with natural conditions yielding the overall composite index. Provides a score 0-100 while also displaying status and trends for each component.
Ecology Sediment Quality Triad Index	Water quality	Moderate	Moderately diagnostic	An index of three sediment components: chemistry, toxicity and sediment-dwelling organisms. Data is collected on both a basin-wide and urban bay scale.
Toxics in fish	Water quality	Moderate	Moderately diagnostic	Measure of persistent bioaccumulative contaminants. Relevant to human health and food web toxic loadings.
Freshwater Macro-invertebrate Index	Water quality	Moderately Low	Non-specific	
Percent of monitored stream flows below critical levels	Water quantity	Moderately high	Moderate	A seasonally-dependant measure of critical stream flow based on historical comparisons. Imperfect measure of water availability. While stream flows are impacted by groundwater, a more direct measure of groundwater availability is needed.

Portfolio C.

Indicator	PSP Goal	Sensitivity	Specificity	Comments
Number of Rockfish	Species and food webs	Low	Moderately non-specific	Analyses testing indicator performance include rockfish as the best indicator for some ecosystem attributes. Like killer whale, there is long response lag because of life history: delayed maturity, slow growth, and long life span. Historical data are available, although not always differentiated by species. 3 rockfishes were recently listed under ESA.
Number of dead sea- and shore birds from beach surveys	Species and food webs	Moderately high	Moderately non-specific	
Number of Jellyfish	Species and food webs	High	Moderate	
Numbers of crabs	Species and food webs	Moderately Low	Diagnostic	
Marine riparian condition	Habitat	Moderate	Moderate	Measures "no net loss of ecological functions" goal as part of Growth Management, and Shoreline Master Plans. Provides estimate of ecosystem process impairment –tied to many eco goods and services
Harmful algal blooms	Habitat	Moderate	Diagnostic	
Land use / land cover	Habitat	Moderate	Diagnostic	Changes in extent and quality of ecological systems; represents threats to obligate species associated with those systems. Tracking land use and cover is consistent with coarse filter approaches to conservation. Also provide estimates of working land conversion rate, impervious surface changes, and changes to habitat, which are part of delisting criteria for salmon and other species
Ecology Freshwater Water Quality Index	Water quality	Moderate	Non-specific	An index of key freshwater quality metrics compared to standards or expected conditions. Metrics include bacteria, pH, temperature, dissolved oxygen,

				nutrients and sediment. Provides a score 0-100. The contribution of individual metrics can be assessed as with all indices.
Ecology Marine Water Quality Composite Index	Water quality	Moderate	Non-specific	An index of key marine water quality metrics compared to expected conditions. Uses a modular approach to generate a eutrophication index which is combined with natural conditions yielding the overall composite index. Provides a score 0-100 while also displaying status and trends for each component.
Ecology Sediment Quality Triad Index	Water quality	Moderate	Moderately diagnostic	An index of three sediment components: chemistry, toxicity and sediment-dwelling organisms. Data is collected on both a basin-wide and urban bay scale.
Toxics in mussels	Water quality	Moderate	Moderately diagnostic	Long-standing, rich data set for measuring trends of toxic contaminants in the marine environment.
Freshwater Macro-invertebrate Index	Water quality	Moderately Low	Non-specific	
Percent of monitored stream flows below critical levels	Water quantity	Moderately high	Moderate	A seasonally-dependant measure of critical stream flow based on historical comparisons. Imperfect measure of water availability. While stream flows are impacted by groundwater, a more direct measure eof groundwater availability is needed.

Leu, M., S.E. Hanser and S. T. Knick. 2008 The Human footprint in the west: a large scale analysis of antorhopodign impacts. Ecological Applications 18: 1119-1139.

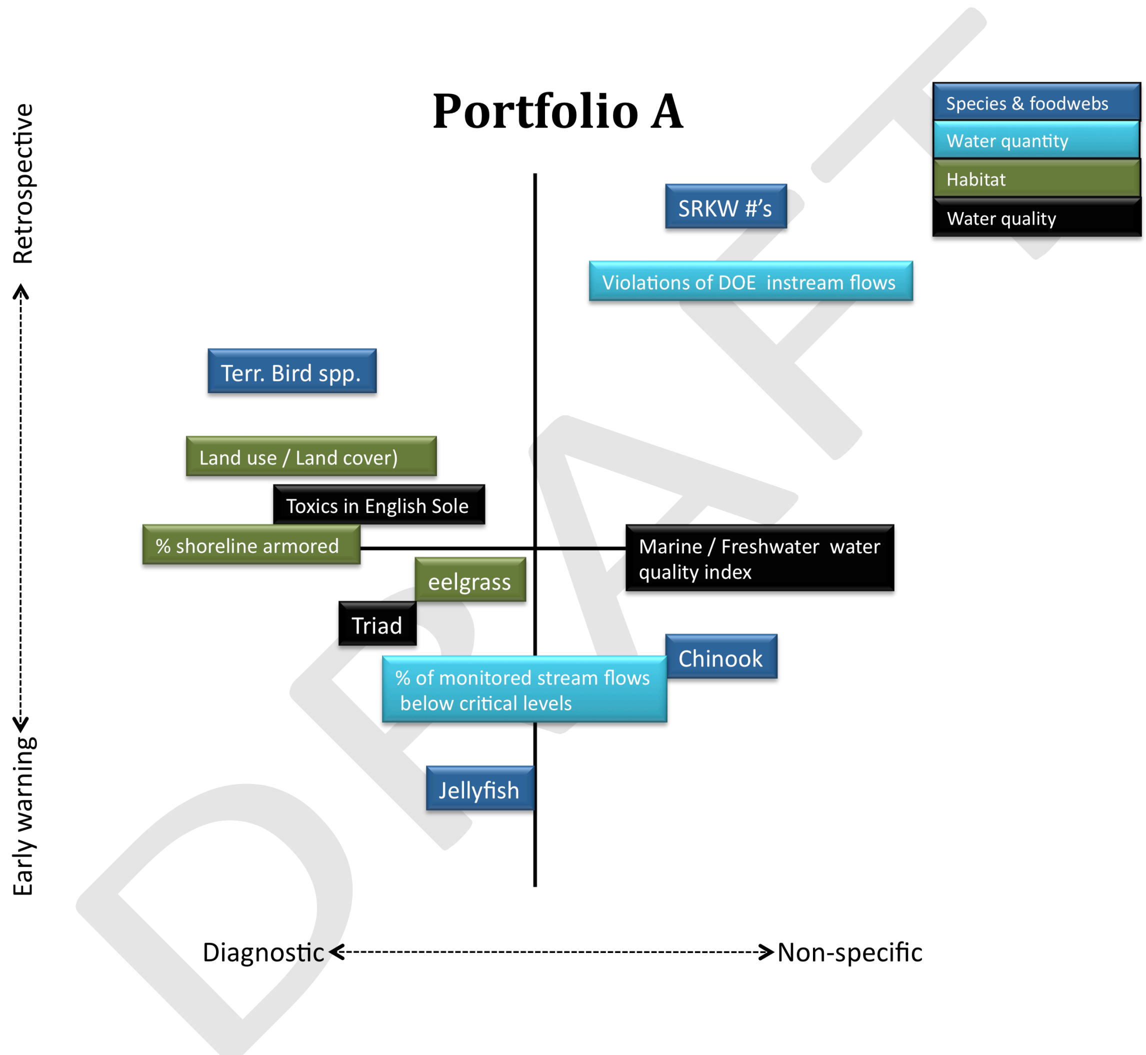

Figure A11. A graphical representation of Portfolio A, showing roughly how indicators line up by PSP goal, specificity (X axis) and sensitivity (Y axis)

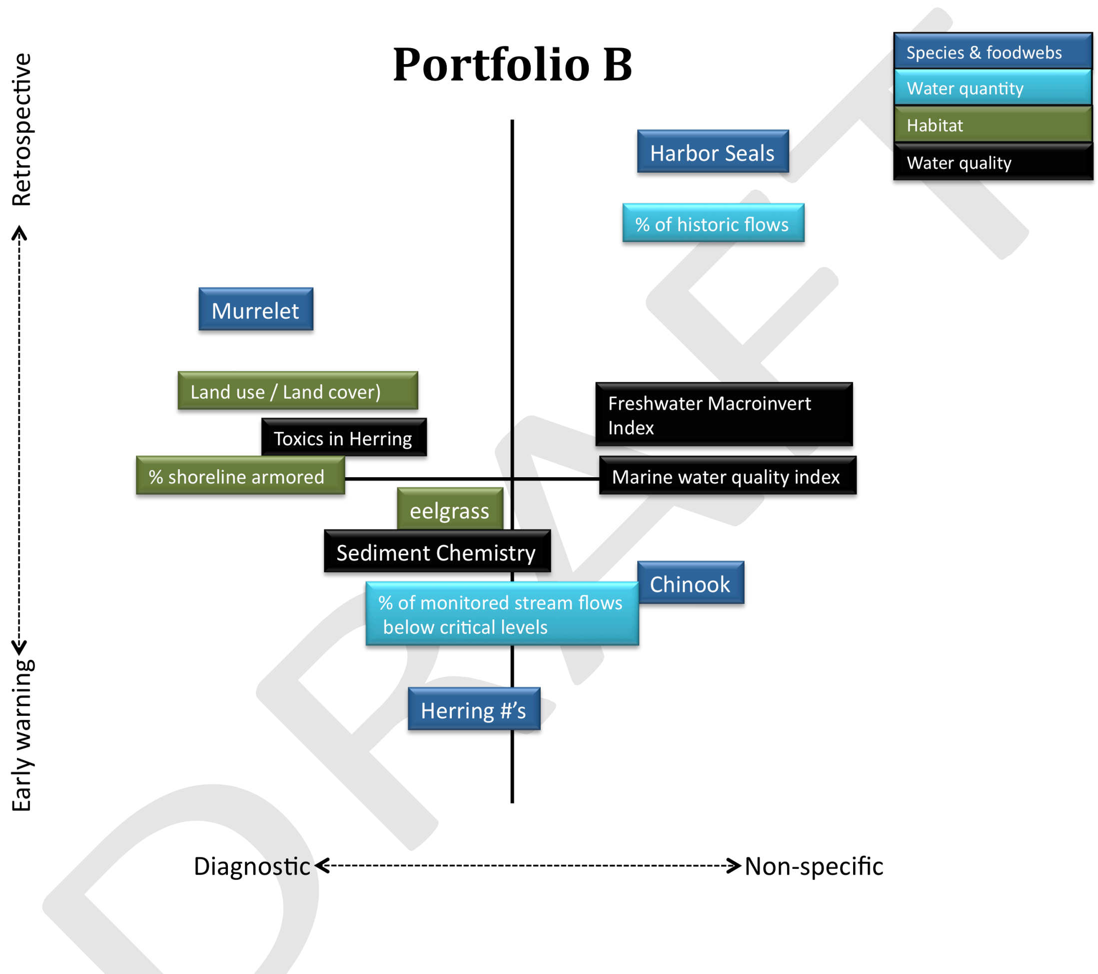

Figure A22. A graphical representation of Portfolio B, showing roughly how indicators line up by PSP goal, specificity (X axis) and sensitivity (Y axis)

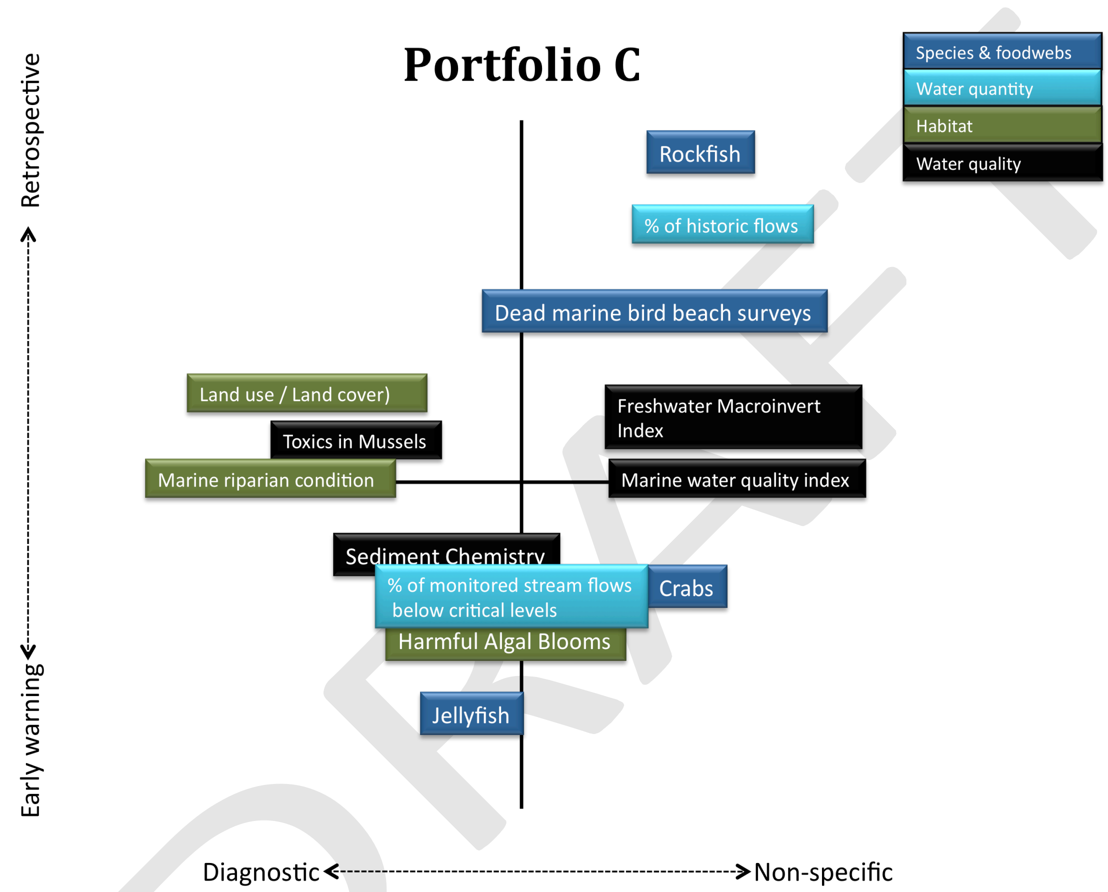

Figure A33. A graphical representation of Portfolio C, showing roughly how indicators line up by PSP goal, specificity (X axis) and sensitivity (Y axis)

Portfolio A

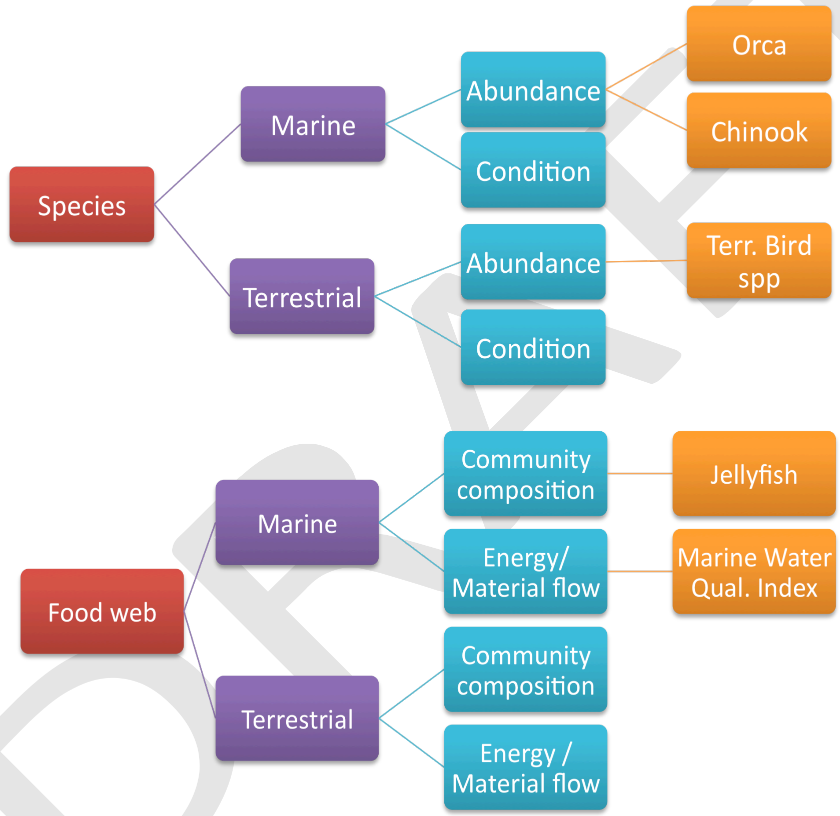

Figure A44a. A graphical representation of Portfolio A, showing how indicators map onto PSP Goals, Ecosystem Components and Key Attributes

Portfolio A

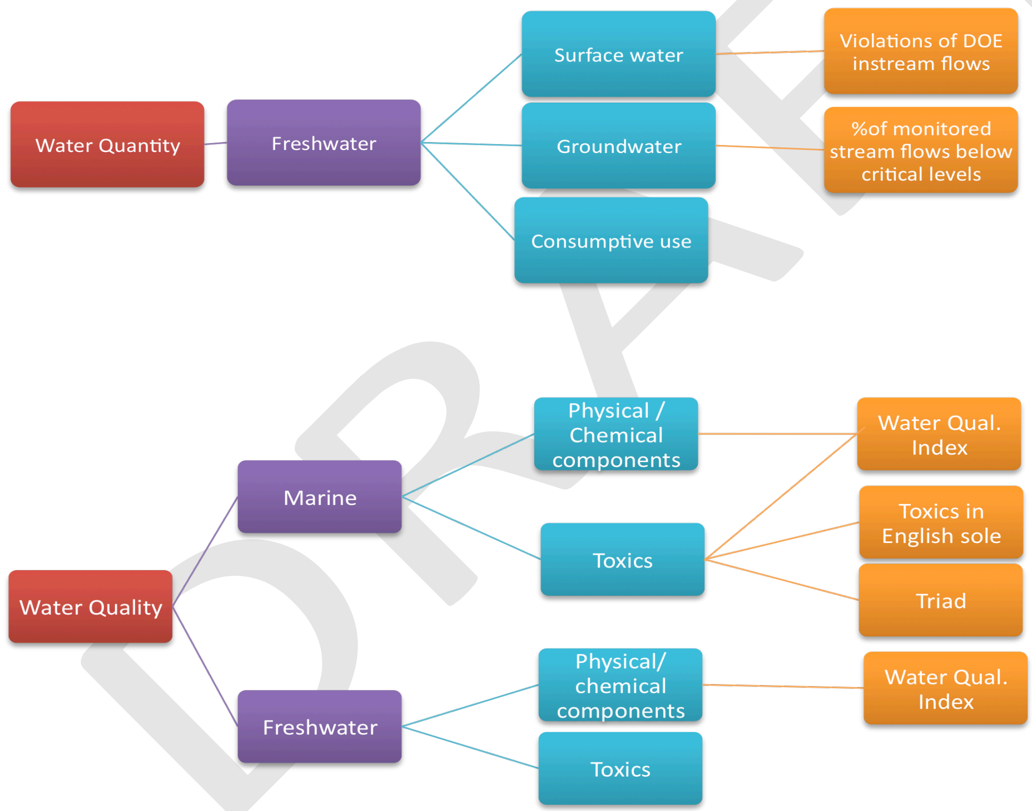

Figure A54b. A graphical representation of Portfolio A, showing how indicators map onto PSP Goals, Ecosystem Components and Key Attributes

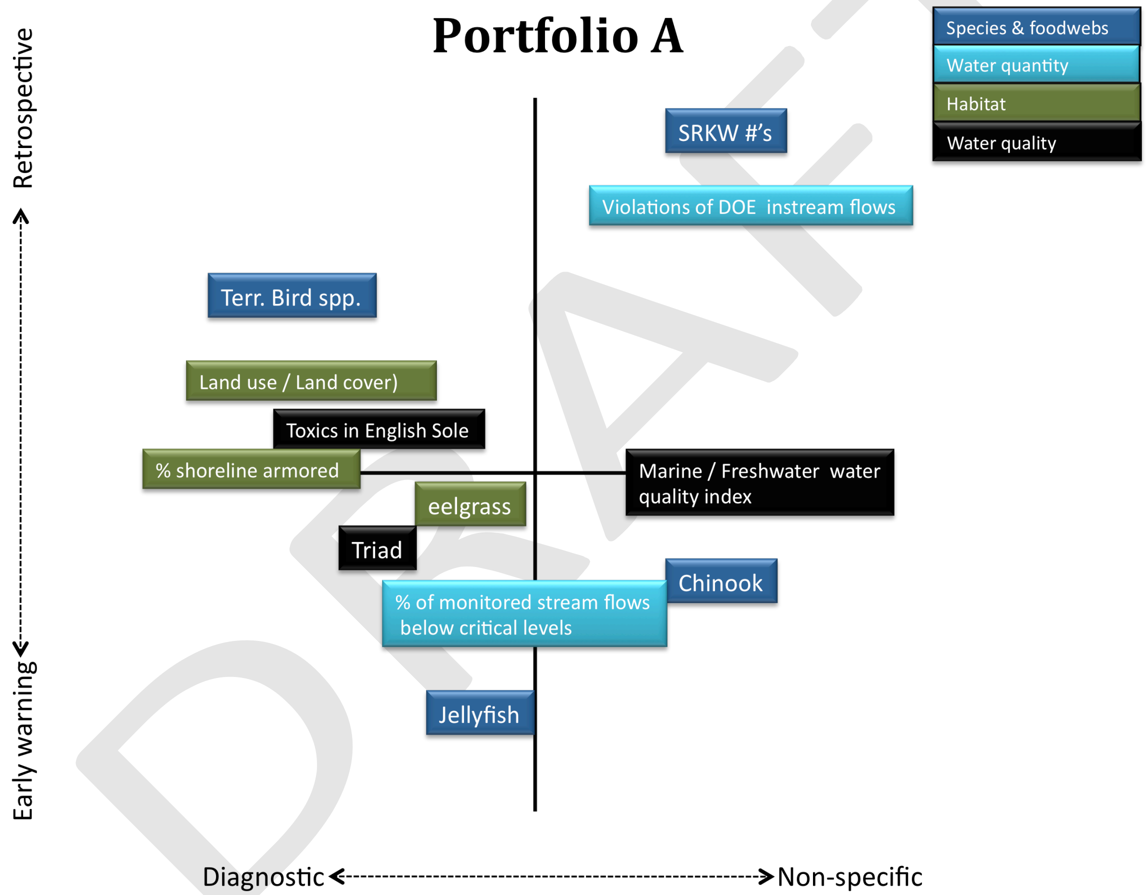

Figure A11. A graphical representation of Portfolio A, showing roughly how indicators line up by PSP goal, specificity (X axis) and sensitivity (Y axis)

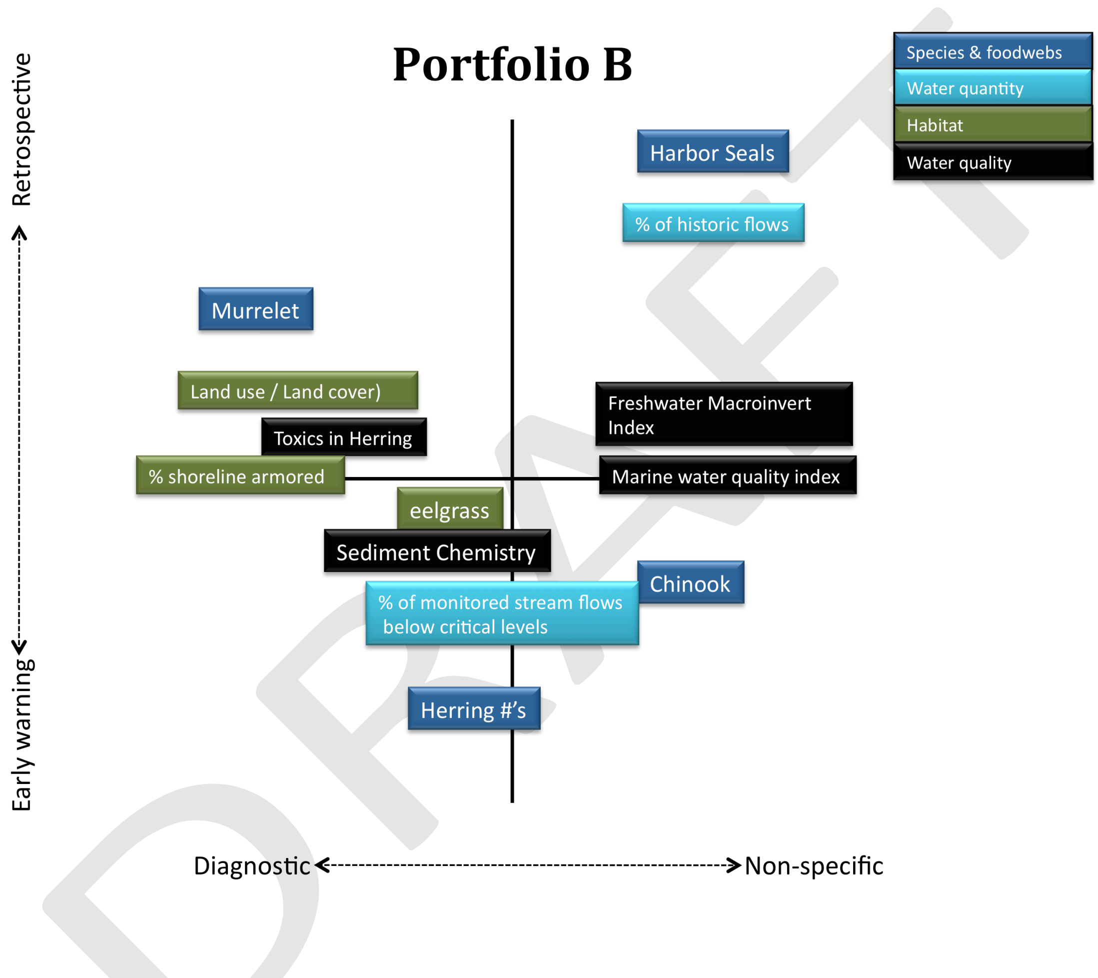

Figure A22. A graphical representation of Portfolio B, showing roughly how indicators line up by PSP goal, specificity (X axis) and sensitivity (Y axis)

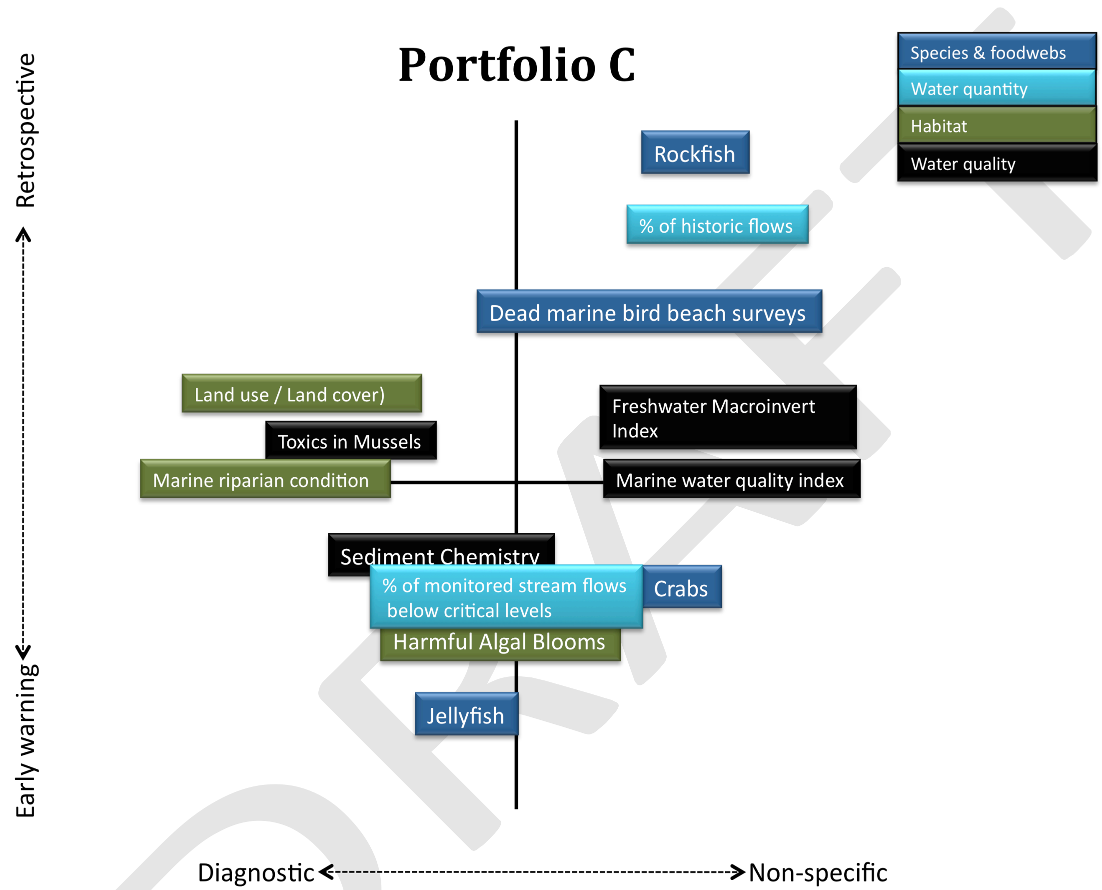

Figure A33. A graphical representation of Portfolio C, showing roughly how indicators line up by PSP goal, specificity (X axis) and sensitivity (Y axis)

Portfolio A

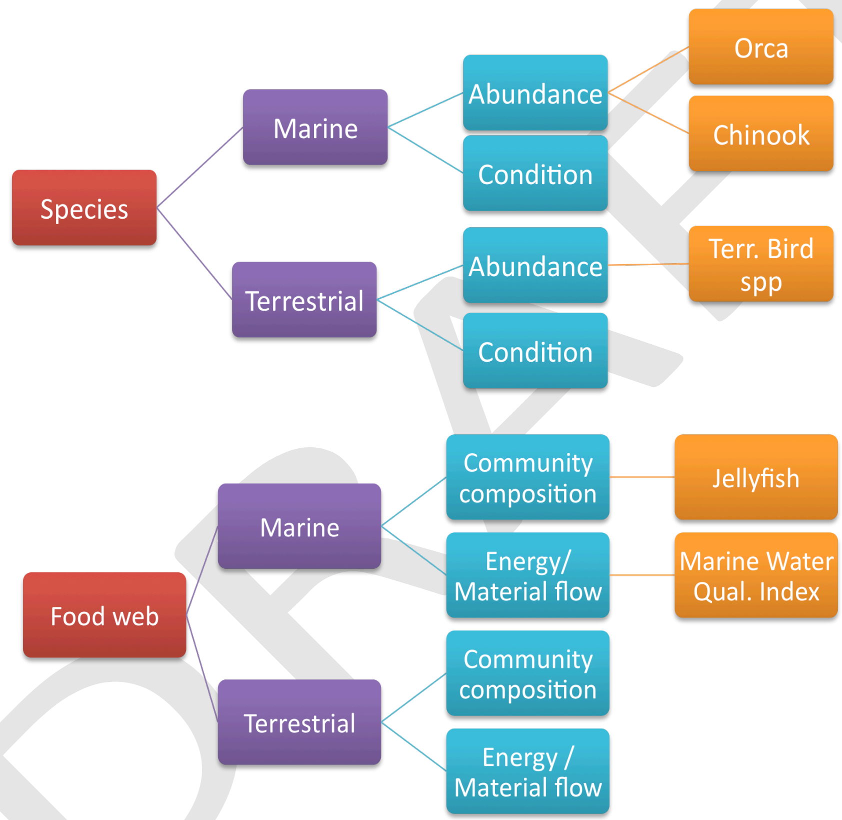

Figure A44a. A graphical representation of Portfolio A, showing how indicators map onto PSP Goals, Ecosystem Components and Key Attributes

Portfolio A

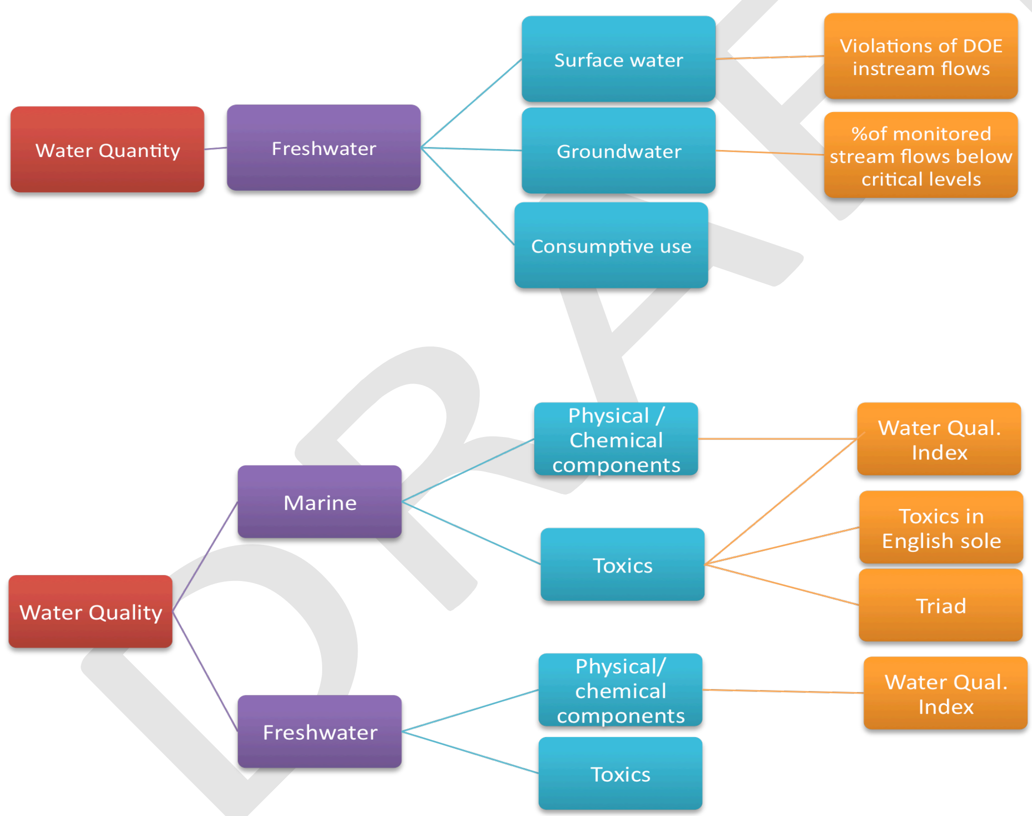

Figure A54b. A graphical representation of Portfolio A, showing how indicators map onto PSP Goals, Ecosystem Components and Key Attributes

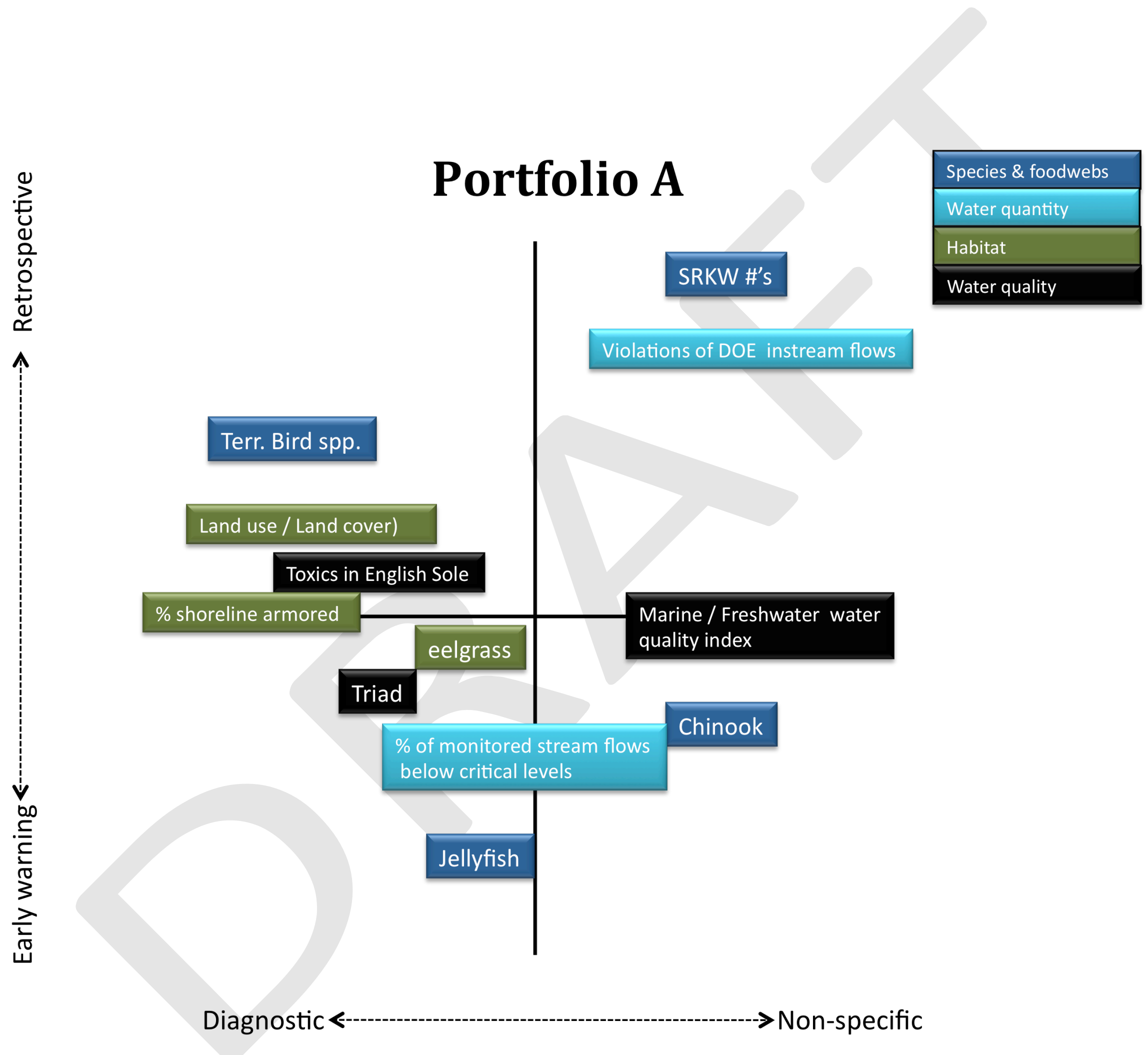

Figure A11. A graphical representation of Portfolio A, showing roughly how indicators line up by PSP goal, specificity (X axis) and sensitivity (Y axis)

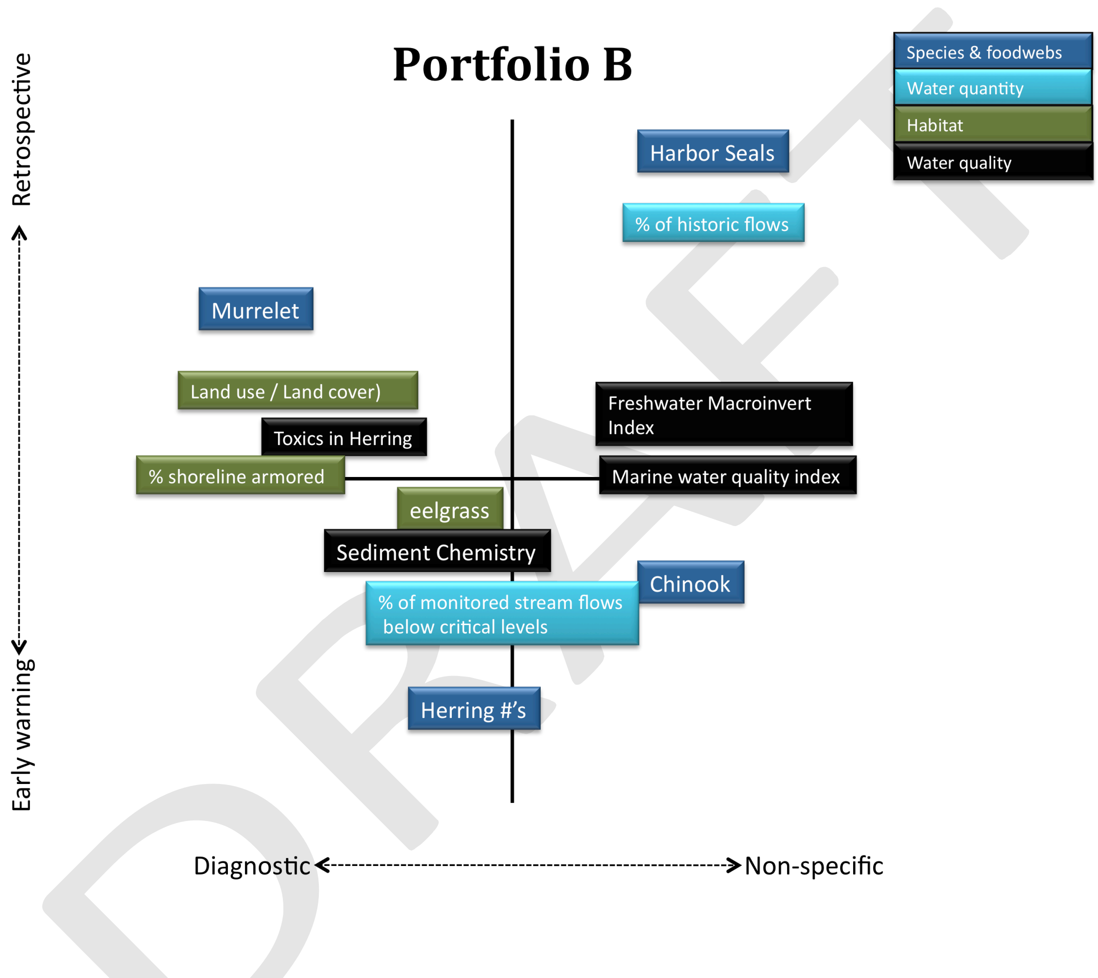

Figure A22. A graphical representation of Portfolio B, showing roughly how indicators line up by PSP goal, specificity (X axis) and sensitivity (Y axis)

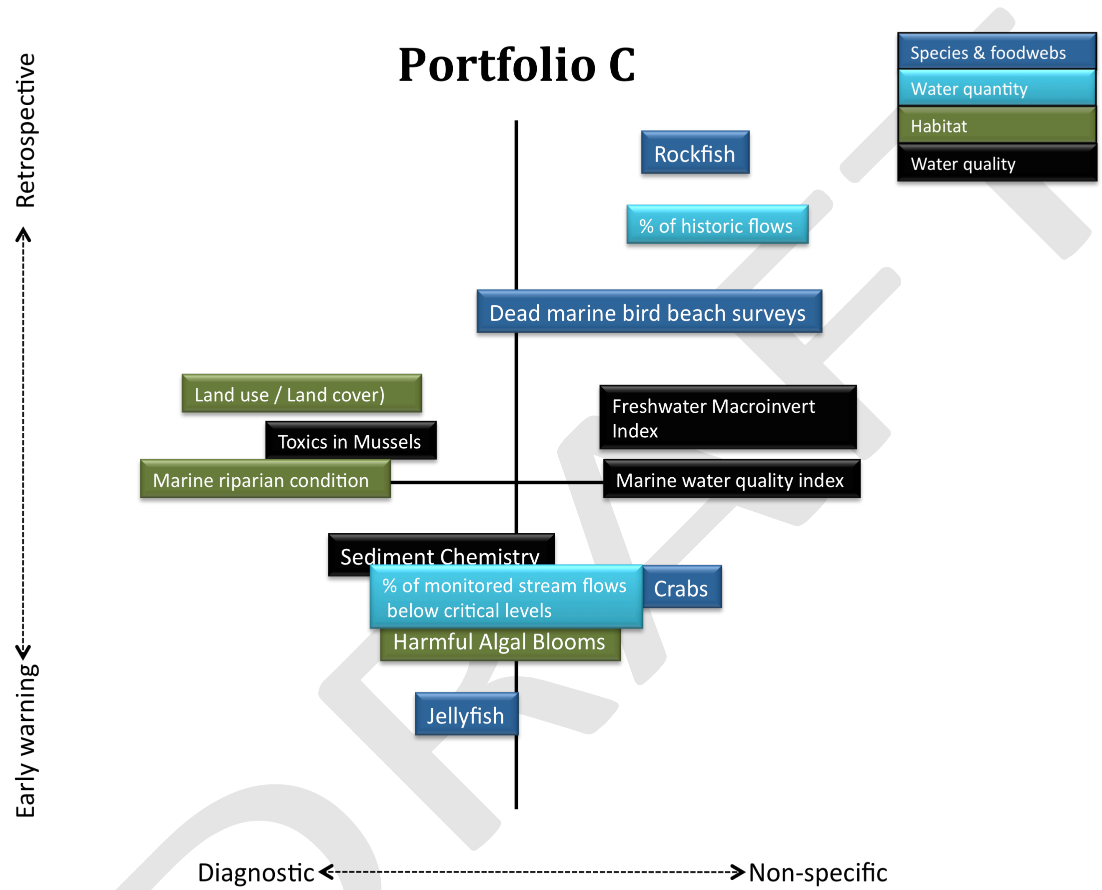

Figure A33. A graphical representation of Portfolio C, showing roughly how indicators line up by PSP goal, specificity (X axis) and sensitivity (Y axis)

Portfolio A

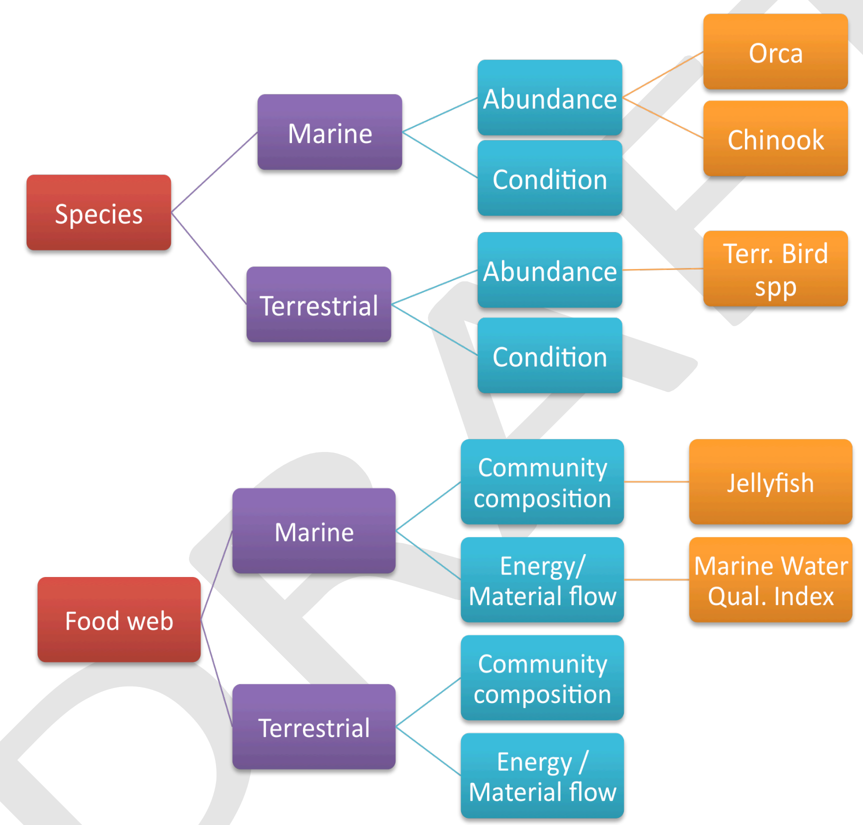

Figure A44a. A graphical representation of Portfolio A, showing how indicators map onto PSP Goals, Ecosystem Components and Key Attributes

Portfolio A

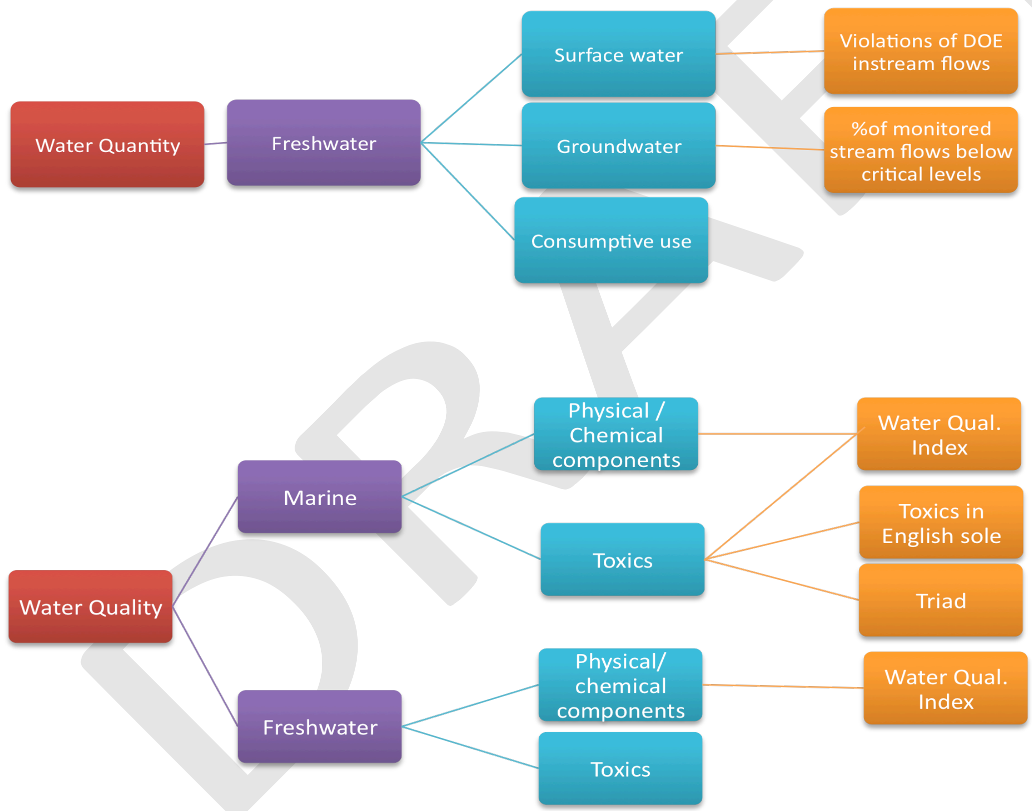

Figure A54b. A graphical representation of Portfolio A, showing how indicators map onto PSP Goals, Ecosystem Components and Key Attributes

Portfolio A

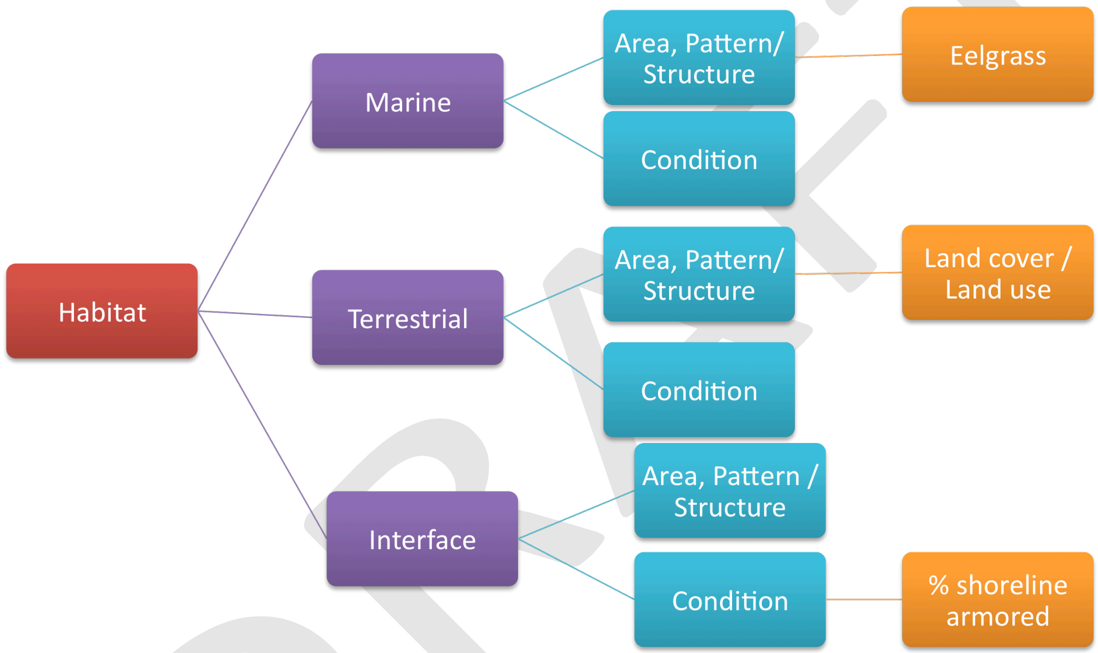

Figure A6. A graphical representation of Portfolio A, showing how indicators map onto PSP Goals, Ecosystem Components and Key Attributes

Appendix B: Indicator Evaluation

The Indicators Action Team began by using the indicator evaluation scheme discussed in Chapter 1 of the PSSU. In the PSSU, indicator criteria were divided into three categories: primary considerations, data considerations, and other considerations. Primary considerations are essential criteria that should be fulfilled by an indicator in order for it to provide scientifically useful information about the status of the ecosystem in relation to PSP goals. Data considerations relate to the actual measurement of the indicator. Other considerations criteria may be important but not essential for indicator performance.

The evaluation criteria are as follows:

Primary considerations

1. **Theoretically-sound**: Scientific, peer-reviewed findings should demonstrate that indicators can act as reliable surrogates for ecosystem attribute(s)
2. **Relevant to management concerns**: Indicators should provide information related to specific management goals and strategies.
3. **Responds predictably and is sufficiently sensitive to changes in a specific ecosystem attribute(s)**: Indicators should respond unambiguously to variation in the ecosystem attribute(s) they are intended to measure, in a theoretically- or empirically-expected direction.
4. **Responds predictably and is sufficiently sensitive to changes in a specific management action(s) or pressure(s)**: Management actions or other human-induced pressures should cause detectable changes in the indicators, in a theoretically- or empirically-expected direction, and it should be possible to distinguish the effects of other factors on the response.
5. **Linkable to scientifically-defined reference points and progress targets**: It should be possible to link indicator values to quantitative or qualitative reference points and target reference points, which imply positive progress toward ecosystem goals.
6. **Complements existing indicators**: This criterion is applicable in the selection of a suite of indicators, performed after the evaluation of individual indicators in a post-hoc analysis. Sets of indicators should be selected to avoid redundancy and increase the complementary of the information provided, and to ensure coverage of Key Attributes.

Data considerations

1. **Concrete**: Indicators should be directly measureable.
2. **Historical data or information available**: Indicators should be supported by existing data to facilitate current status evaluation (relative to historic levels) and interpretation of future trends.
3. **Operationally simple**: The methods for sampling, measuring, processing, and analyzing the indicator data should be technically feasible.

4. **Numerical**: Quantitative measurements are preferred over qualitative, categorical measurements, which in turn are preferred over expert opinions and professional judgments.
5. **Broad spatial coverage**: Ideally, data for each indicator should be available in all PSP Action Areas.
6. **Continuous time series**: Indicators should have been sampled on multiple occasions, preferably without substantial time-gaps between sampling.
7. **Spatial and temporal variation understood**: Diel, seasonal, annual, and decadal variability in the indicators should ideally be understood, as should spatial heterogeneity/patchiness in indicator values.
8. **High signal-to-noise ratio**: It should be possible to estimate measurement and process uncertainty associated with each indicator, and to ensure that variability in indicator values does not prevent detection of significant changes.

Other considerations

1. **Understood by the public and policymakers**: Indicators should be simple to interpret, easy to communicate, and public understanding should be consistent with technical definitions.
2. **History of reporting**: Indicators already perceived by the public and policymakers as reliable and meaningful should be preferred over novel indicators.
3. **Cost-effective**: Sampling, measuring, processing, and analyzing the indicator data should make effective use of limited financial resources.
4. **Anticipatory or leading indicator**: A subset of indicators should signal changes in ecosystem attributes before they occur, and ideally with sufficient lead-time to allow for a management response. (why just a subset here? Is it because it is unlikey to get all leading indicators and still get coverage across broad range of attributes?
5. **Regionally/nationally/internationally compatible**: Indicators should be comparable to those used in other geographic locations, in order to contextualize ecosystem status and changes in status.

PSSU authors assessed each indicator against each evaluation criterion by reviewing peer-reviewed publications and reports. They chose the benchmark of peer-reviewed literature because it was consistent with the criterion of peer-review used the Puget Sound Science Update, and it was a criterion that was relatively easy to apply in a consistent fashion. However, the PSSU also included documentation of non-peer-reviewed support for indicators, and the Indicators Action Team, considered this as well.

Coarsely Rank Indicators

Chapter 1 of the PSSU provides the raw materials and suggests an approach for ranking indicators, but does not do so. The Indicator Action Team chose to apply the PSSU approach to the 100's of indicators suggested by different PSP indicator processes. Ranking requires careful consideration of the relative importance of evaluation criteria (since, of course failure to weight criteria is a decision to weight all criteria equally)

The Indicator Action Team used a weighting scheme for the indicator criteria that ranged from 0 to 1.0 that they felt reflected the aim of the dashboard. The weighting scheme is as follows:

Criteria	Weight
Theoretically-sound	0.5
Relevant to management concerns	1
Responds predictably & is sufficiently sensitive to changes in a specific ecosystem attribute(s)	0.5
Responds predictably & is sufficiently sensitive to changes in a specific management action(s) or pressure(s)	0.5
Linkable to scientifically-defined reference points & progress targets	0.75
Concrete	0.75
Historical data or information available	1
Operationally simple	1
Numerical	1
Broad spatial coverage	0.5
Continuous time series	1
Spatial & temporal variation understood	0
High signal-to-noise ratio	0
Understood by the public & policymakers	1
History of reporting	0.5
Cost-effective	0.5
Anticipatory or leading indicator	0
Regionally/nationally/internationally compatible	0.25

Time constraints prevented a full exploration of alternative weighting schemes. However, the goal of the ranking was not to finely separate individual indicators; rather, the aim was to generate a list of "top tier" indicators. Examination of two very different weighting schemes revealed that the "top tier" indicators do not differ among weighting schemes (although the rank order of indicators does shift).

The team then scored each indicator as 1.0 when there was peer-reviewed evidence that that it met a criterion. When there was non-peer reviewed or ambiguous evidence that an indicator meets a criterion we gave it a score of 0.5. When it did not meet a criterion, it received a score of 0. This score was then multiplied by the criterion weighting, to produce a weighted score for each criterion. Weighting scores were then summed for all criteria to produce an overall ranking score.

In some instances Indicator Action Team members brought forward new indicators that had not yet been evaluated by the PSSU. These were treated as if they were "top tier." The water quality index included in Portfolio A was such an indicator.

Appendix C: Human Well-Being Indicators

One of the six statutory goals of the Puget Sound Partnership is "A quality of human life that is sustained by a functioning Puget Sound ecosystem". Section 1. (C) of Engrossed Substitute Senate Bill 5372, the enabling legislation for the Puget Sound Partnership states:

"Puget Sound must be restored and protected in a more coherent and effective manner. The current system is highly fragmented. Immediate and concerted action is necessary by all levels of government working with the public, nongovernmental organizations, and the private sector to ensure a thriving natural system that exists in harmony with a vibrant economy."

Therefore, in order to demonstrate that Puget Sound recovery can occur in the midst of one of our nation's and the Pacific Rim's most economically active and productive urban areas, home to about four million people (not counting Canadian drainages to the basin), the Washington State Legislature recognized that it is necessary to develop indicators that gauge human well-being and health as we also evaluate progress on protecting and restoring the region's natural systems.

The process of generating indicators of human well-being began in 2008 and has been ongoing in a variety of different forums since that time. The human well-being indicators found in the Draft Ecosystem Indicators Dashboard are based on the expert opinion of the authors of this memo in consultation with social scientists from various disciplines and informed by previous work conducted over the last 2 years. Previous work included a literature review on human well-being indicators, a ranking of potential indicators using criteria established by the NOAA NW Fisheries Science Center staff (O'Neill, Bravo and Collier, 2008), input from social scientists and stakeholders in the Performance Management/ Open Standards process conducted by PSP staff (PSP, 2009), and a review of human well-being indicators in Part 2b of the PSP Science Update (Mercer et al, 2010). Each of these efforts is briefly described below.

Literature Review and Provisional Indicators of Human Well-being: A comprehensive literature review was conducted in 2008 by Morgan Schneidler who was at the time employed by the NW Fisheries Science Center. The literature review was designed to identify a comprehensive list of human well-being indicators that addressed the quality of life goals of the PSP. Morgan Schneidler, Mark Plummer (NW Fisheries Science Center) and Katharine Wellman (Northern Economics, Inc, and PSP Science Panel Member) worked with the original Provisional Indicators Task Group led by Sandi O'Neill. This group generated a set of possible indicators for human well-being. These indicators were divided into subsets according to a general scheme for ensuring coverage of distinct elements of human well-being (Please see Schneidler and Plummer, 2009). For each subset, the task group listed potential indicators that fall into four categories:

- Good Provisional Indicator: Indicators that satisfy the criteria listed in "*Criteria and Framework for Selecting Provisional Environmental Indicators*" or *Criteria (Bravo and O'Neill, 2008)*.
- Potential Indicators: Indicators that satisfy some but not all of the criteria identified in *Criteria.*
- Indicators from other Group: Indicators that are being used by other groups but also can be used for human well-being

- Future Work: Areas where future work needs to be done to develop indicators.

Open Standards Performance Management Indicators of Human Well-being: Mark Plummer and Katharine Wellman worked with the PSP Cross Partnership Performance Management Work Group to identify appropriate human well-being focal components within the context of the Open Standards Process (Conservation Measures Partnership, 2007) in 2009. A short list of focal components were generated, including (1) the built environment, (2) working marine industries, (3) working resource lands and industries, (4) nature oriented recreation, (5) aesthetics, scenic resources and existence values. Please see the list of indicators under each of these focal components in PSP (2009). Refinement and identification of data sources for related indicators was only completed for two of these components (Working Marine Industries and Working Resource Lands and Industries). The two indicators selected for inclusion in the 2009 State of the Sound (PSP, 2010) were Puget Sound Commercial Finfish and Shellfish Harvest and Forestland Acreage.

One recommendation that the Indicators Action Team has as Puget Sound recovery efforts advance is for the Partnership to fully flesh out the Open Standards process and to select a detailed set of related strategies and indicators so that the results may serve as the backbone and logic supporting the next generation of the Action Agenda. The authors believe that this set of logically derived, connected and prioritized strategies and indicators should fully embrace human health and well-being as intended in the original enabling legislation. Doing so will provide the Partnership and those tasked with implementation of the Action Agenda a clear path from objectives, strategies and challenges through measure of success, and the ability to track condition of both the human and natural dimensions of the Puget Sound system as we go forward.

PSP Science Update: Doug Mercer and colleagues (2010) are in the process of generating a chapter for the Puget Sound Science Update. Their work has focused on indicators of demographic change in the Puget Sound region and develops a compelling argument for the inclusion of indicators of institutional change and social capital. However, there are not adequate data sources for the latter. This work informed the PSP Indicators Action Team but was not in complete enough form to be adequately integrated into the Draft Ecosystem Indicators Dashboard.

Draft Ecosystem Indicators Dashboard – Human Well-being and Human Health Indicators: Based on the former efforts and further refinement of data availability and recognition of potential overlap with natural system indicators, the Indicators Action Team has identified 4 dashboard indicators for human well-being, and 1 for human health (see Draft Ecosystem Indicators Dashboard, 2010). These indicators were chosen to represent one or more of each of the following 6 "Strategic Outcome Measures" (using the language of the Indicators Action Team but also referred to as "Focal Components" in Open Standards (Conservation Measures Partnership, 2007) terminology). This list of strategic outcome measures has reoccurred throughout nearly all the work on human well-being indicators over the last 3 years, and a focus of discussion among various PSP workgroups. They include:

7. Regional makeup (including demographics, economic, water use and transportation trends).
8. Social capital (e.g. environmental stewardship, citizen scientists).
9. Impact of recovery strategies on marine and land based natural resource industries (unintended consequences of Action Agenda implementation)
10. Ecosystem services which provide benefits to people
11. Behavioral change of public as awareness increases
12. Existence value of the ecosystem (including aesthetics and willingness to pay to assure the continued survival of individual species or general health of the ecosystem)

Table 1 lists the 6 strategic outcome measures or “Components” (and associated indicators where possible) identified by the authors and vetted with members of the Indicators Action Team, Doug Mercer, and Mark Plummer. For the purposes of our 2010 Dashboard, indicators with current robust data sources were selected for 4 of the 6 strategic outcome measures:

- Regional makeup – Puget Sound Regional Council Index (please see attached)
- Impact of recovery strategies on marine and land based natural resource industries – Commercial Fisheries Harvest (Tribal and Non-Tribal)(annual wild harvest in pounds)
- Ecosystem services which provide benefits to people – Participation in recreational fish, shellfish and hunting harvest (number of permits issued)
- Behavioral change of public as awareness increases – Personal vehicle miles traveled

The Indicators Action Team members tasked with working on indicators of human well-being recommend advancing at this time the current proposed list of four indicators plus a fifth related to human health and water quality: (the percent of core swimming beaches meeting water quality standards). Going forward, however, we suggest the Puget Sound Partnership and its advisors review this list at least annually, and improve the existing indicators, or add or subtract indicators as needed to effectively represent progress to the public. The authors feel strongly that indicators of working resource lands (agriculture, timber, and aquaculture), existence value and social capital need to be developed and eventually added to the Dashboard to characterize these important dimensions of human engagement and value of the Puget Sound ecosystem. We also suggest that there may be a better indicator of behavioral change. We also believe there is much to be gained with respect to improving existing Indexes of human well-being by either expanding or contracting the geographic range evaluated using the existing underlying data sets. While we recommend the Puget Sound Trends Index for the current Dashboard it could be significantly improved by including coverage of all 12 adjacent counties. Another example of note is the Cascadia Scorecard developed for the international geography of the Cascade mountain range and adjacent marine environment developed by the organization Sightline. In addition to examining metrics of wildlife condition or pollution, these indexes include a combination of measures that address trends in human health, economy, demographics, land use, energy consumption and transportation. Rescaling or calibrating the underlying datasets so that they coincide with the Puget Sound basin as a whole, and/or match each of the eight action areas identified in the enabling legislation, these indexes or some derivation of their metrics could prove to be tremendously valuable in measuring important and relevant human dimensions as Puget Sound recovery progresses.

Table C1. Human Dimension Indicators

Component	Indicator	Operational definition	Comments
Regional makeup	Human Well-being Index	Puget Sound Regional Council Puget Sound Trends Index (see attached for entire list of attributes)	• This index reflects what is guiding the region's economic development and sustainable growth goals • it exists and data is being collected and reported monthly – Rick Olsen ROlson@psrc.org • Includes four counties (King, Kitsap, Snohomish, and Pierce) • there is nothing like it elsewhere that covers the geographic scale and time frame that we need
Behavioral Change	Personal Vehicle Miles	Personal Vehicle Miles Traveled extracted from the Index to represent Changes in Behavior strategic outcome Measure.	
Action Impact	Commercial Fisheries	Annual harvest (pounds) of non-tribal commercial fisheries (salmon, crab, shellfish, groundfish, shrimp) in Puget Sound.	• PacFin database reported annually by Pacific Marine Fisheries Commission.

Action Impact	Working Agricultural Lands	Percent of State and Private Forestlands converted to other uses	• NOAA C-CAP data source (see attached) • Alternative future data source is UW Precision Forestry Cooperative Western Washington Land Use Change Data Set: WA State Parcel Data Base (2007 2009) and WA State Forestland Data Base (2007). These to be expanded to include parcel data on agriculture pending funding. • The latter would be very helpful in evaluating alternative land use outcomes associated with different policy scenarios as well.
Action Impact	Working Forest Lands	Percent of private agricultural lands converted to other uses OR Hired Farm labor or number of people employed in agriculture production	• Future data source is UW Precision Forestry Cooperative Western Washington Land Use Change Data Set: WA State Parcel Data Base (2007 2009) and WA State Forestland Data Base (2007). These to be expanded to include parcel data on agriculture pending funding. Recommended to be added to Monitoring Program. • The latter would be very helpful in evaluating alternative land use outcomes associated with different policy scenarios as well • If interested in number of people employed in agriculture production data source is Census of Agriculture Washington State County Level data

Ecosystem Services	Number of recreational fishing permits sold annually in Puget Sound	• WDFW recreational fishing permit sales - data collected by license type, year issued and number of licenses – Eric Kraig- Eric.Kraig@dfw.wa.gov • Participation rates are indicative of the quality of the recreational experience and access to the resource….lots to harvest (less management restrictions and shellfish beds closed) the greater the participation • 2006 (most recent) Outdoor Recreation Survey, Washington State Recreation and Conservation Office. Recreational regions and data collected by counties every five years. • Present data in stacked form
Social Capital, Existence Value		• Data not currently being collected • Rational for its measurement well-documented in the scientific literature • Social capital might be measured as number of individual membership in environmental organizations, citizen science groups, philanthropic foundations and professional employment • Existence values could be assessed though a willingness to pay survey

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Bravo, C. and S. O'Neill. 2008. Criteria for Indicator Selection from the Provisional Indicators Technical Working Group. NOAA Fisheries Science Center.

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O'Neill, C.F. Bravo, and T. K. Collier. 2008. Environmental Indicators for the Puget Sound Partnership: A Regional Effort to Select Provisional Indicators (Phase 1). Summary Report. NOAA Fisheries, NW Fisheries Science Center.

Puget Sound Partnership. 2009. Identification of Ecosystem Components and Their Indicators and Targets. Technical Memorandum.

Puget Sound Partnership. 2010. State of the Sound.

Schneidler, M. and M. Plummer. 2009. Human Well Being Indicators in Puget Sound. NOAA Fisheries, NW Fisheries Science Center

Puget Sound Trends Index

A monthly report of demographic, economic, transportation and other planning data of interest to government, business and industry in the Puget Sound region

April 2010 Trend: Employment in Manufacturing-Industrial Centers, 2000-2008

Demographic Trends

Mar 2010	2008 Residential Building Permit Trends	D4
Sep 2009	Population of Cities and Towns [available in Excel]	D3
Apr 2008	Development Patterns Shift Under Growth Management	D5
Feb 2007	Population Change and Net Migration	D7
May 2006	Trends in Household Size	D11
Mar 2006	Population Trends	D2
Jan 2006	Educational Attainment in the Central Puget Sound Region	D10
May 2005	Characteristics of Migration for the Puget Sound Region	D8
Jul 2001	Population Change in Cities, Towns, and Counties, 1990-2000	D6
Jul 2001	Historical County Population Change, 1950-2000	D1

Economic Trends

Apr 2010	Employment in Manufacturing-Industrial Centers, 2000-2008	E7
Oct 2009	Employment in Regional Growth Centers, 2000-2008	E13
Aug 2009	Housing Prices and Affordability	E16
Dec 2008	Prosperity Partnership's Indicators Highlight Areas of Change	E6
Aug 2008	Employment Change in Puget Sound, 2006-2007	E2
Nov 2007	Recession and Rebound in Target Industry Groups (Clusters), 2000-2006	E5
Nov 2006	Personal Income and Inflation, 1995-2004	E4
Aug 2006	Wages in Central Puget Sound 1995, 2000-2004	E14

Jun 2006	High-Tech Employment	E10
Oct 2005	Nonagricultural Wage and Salary Employment Growth, 2004-2005	E15
Nov 2002	Poverty Status in Puget Sound Region	E12
Oct 2002	Changes in Housing Affordability	E11
Oct 2001	Per Capita and Total Personal Income, 1970-1999	E3
Nov 1999	Services Employment Drives Diverse Regional Economy	E9
Oct 1999	Wage and Job Growth in the Central Puget Sound Region	E8

Environmental Trend

Nov 2008	Emission Trends in the Central Puget Sound Region	G1

Transportation Trends

Jan 2010	HOV Travel Times	T13
Jan 2010	Commute Trip Reduction and Telework	T16
Jul 2009	Bicycling and Walking in the Central Puget Sound Region	T17
Jun 2009	Transit Ridership	T6
Jun 2009	Ferry Ridership	T4
May 2009	Car and Truck Speeds on Freeways	T14
Apr 2009	Major Park-and-Ride Lot Utilization in the Central Puget Sound Region	T12
Jan 2009	Household Travel Survey Comparison Report	T3
Sep 2008	Trends in Vehicle Miles Traveled	T2
Jul 2008	Travel Characteristics for Puget Sound Residents	T9
Mar 2008	Comparing Population, Commute and Freight Patterns in the Puget Sound and Five Peer Regions	T11
Dec 2007	Average Distance to Work	T10
Oct 2007	Mode of Travel	T8
May 2007	Traffic Volumes Mixed While Regional Employment Rises	T20

Jan 2007	Parking Trends for the Central Puget Sound Region, 2004-2006	T7
Apr 2006	Historical Ferry Fares	T15
Aug 2004	Origin of Work Trips to the Region's CBDs	T24
Apr 2004	Puget Sound Gets More Connected – Use of Travel Information Services on the Rise	T23
Mar 2004	Commuting to the Region's Downtown Areas	T22
Nov 2003	Census 2000 Data Illustrate Diverse Commute Modes	T21
Apr 2003	1980, 1990, and 2000 County-Level Journey to Work	T1
Jul 2002	Number of Vehicles Per Household	T19
Jun 2002	Traffic Increases in Response to Regional Population and Employment Growth, 1990-2000	T5
Feb 2002	Commute Trends	T18

Coastal Change Analysis Program Regional Land Cover

Produced and distributed by the NOAA Coastal Services Center

The Coastal Change Analysis Program (C-CAP) produces a nationally standardized database of land cover and land change information for the coastal regions of the U.S. C-CAP products provide inventories of coastal intertidal areas, wetlands, and adjacent uplands with the goal of monitoring these habitats by updating the land cover maps every five years. C-CAP products are developed using multiple dates of remotely sensed imagery and consist of raster-based land cover maps for each date of analysis, as well as a file that highlights what changes have occurred between these dates and where the changes were located.

NOAA also produces high resolution C-CAP land cover products, for select geographies. These products focus on bringing NOAA's national mapping framework to the local level, by providing complimentary data, at a more detailed resolution to compliment regional C-CAP land cover. However, high resolution of C-CAP data is not currently collected in the Puget Sound Region.

Data Specifications

- **Area of Coverage:** Coastal intertidal areas, wetlands, and adjacent uplands of the contiguous U.S., Puerto Rico, the U.S. Virgin Islands, Hawaii, and the Pacific Islands territories
- **Date(s) Available:** 1992, 1996, 2001, and 2005 (vary by location)
- **Format:** IMG, GeoTIFF, GoogleEarth KMZ
- **Resolution/Scale:** 30 meter pixels (1:100,000)
- **Minimum Mapping Unit:** 30 meter pixels (1/4 acres)
- **Accuracy:** Developed to meet an 85 percent overall target accuracy specification but can vary by geography and date.